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(54) Title: OPTICAL AMPLIFIER CONTROL
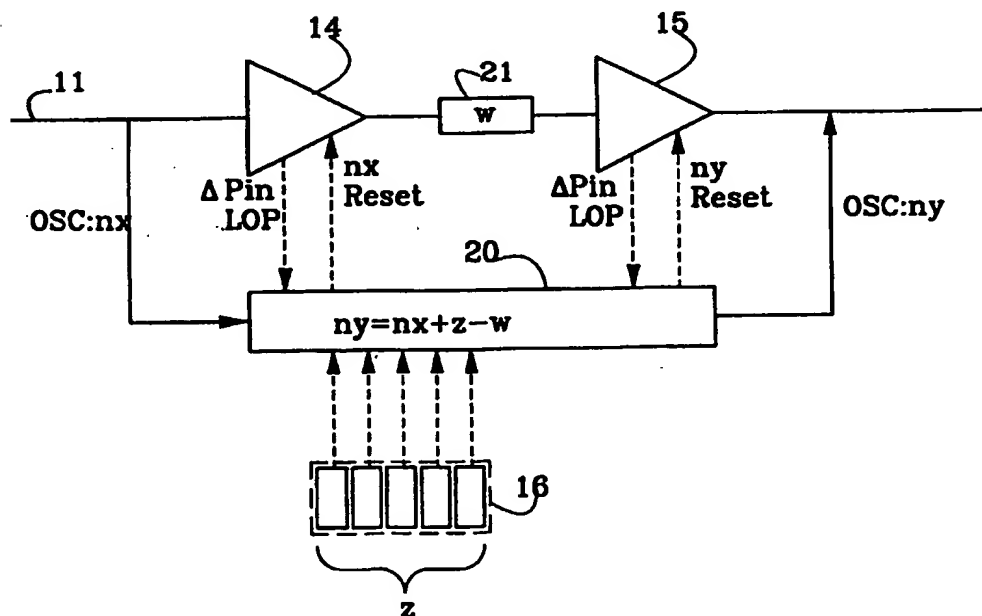
(57) Abstract

The present invention relates to a method for controlling the output power of an optical amplifier (14, 15) in a node (N1, N2, N3, N4, N5, N6) in a network, wherein output power of the amplifier (14, 15) is controlled via a pump laser (32) in a control circuit. According to the invention the node (N1, N2, N3, N4, N5, N6) reads a supervisory channel (OSC), comprising information on how to control the amplifier (14, 15). The node (N1, N2, N3, N4, N5, N6) then uses said information for the control of the amplifier (14, 15).

OPTICAL AMPLIFIER CONTROL

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a method for controlling the output power of optical amplifiers, particularly in nodes in a network, and to a node in a network.

5   **DESCRIPTION OF RELATED ART**

Wave Division Multiplexing (WDM) is a technology allowing the transmission of a number of optical signals through an optical fibre using different separated light wavelengths. In this way the information carrying capacity may be

10   increased significantly. The capacity depends on the bandwidth of the channels and the number of used wavelength channels. The signal at each wavelength travels through the fibre irrespectful of the other signals, so that each signal represents a discrete channel with large bandwidth.

15   When signals are sent long distances the signals have to be regenerated or optically amplified at intervals. An optical amplifier may comprise an erbiumdoped fibre that is being pumped by a high power semiconductor laser, here called "pump laser" for short.

20   The optical amplifier differs from the electrical amplifier in that the optical amplifier strives to keep a constant output power, since they normally are in a more or less saturated state, while the electrical amplifier has constant gain.

25   That the output power is constant gives problems if the number of channels are changed - by purpose or by a fault. It may therefore be desirable to be able to control the output power.

It is earlier known to control the gain in an optical amplifier by using pilot tones, see EP 0 637 148 A1. An identifying pilot tone is being modulated on each multiplexed wavelength. Each amplifier in the system decides
5   from the pilot tone the total number of sent wavelengths and therefore gives a corresponding control of the gain of the amplifier. Either feedforward or feedback is used. In the document is also hinted that in the addition to the count of the number of channels the amplitude of the pilot tones
10   could be measured to obtain a better control.

It is also earlier known, see GB 2 294 170, to control the amplifier in different ways by measuring total optical effect on the output of the amplifier, transforming it to a voltage and comparing it with a reference voltage. This
15   gives a feedback signal that controls the amplifier. As an addition the number of channels may be counted and the control may be adjusted accordingly.

Further it is known, see US 4,991,229, to control an optical amplifier by measuring the power in only one wavelength
20   channel. This is done by filtering out said channel with the aid of a WDM-coupler and then detecting the channel. Otherwise, feedback is made on a similar way as above.

In US 5,113,459 is shown an idea of using a special channel for optical service signalling.

25   **SUMMARY**

The problems with modulating identifying pilot tones on each multiplexed wavelength in order to be able to count the wavelengths is that it is complicated, slow and expensive.

Another problem is that it also influences the transmission performances in a negative way.

The purpose of the present invention is to provide a simple and effective power per channel control of amplifiers in nodes in a network forming a bus. In order to do that a simple, fast and cheap way of counting the channels entering each amplifier is accomplished.

The counting of channels is achieved by using a separate channel for signalling between the nodes, wherein the number n of channels is transmitted between the nodes. An alternative would be to use a separate electrical network, which however is slower.

The first node of the bus sets the number n to the number of active transmitters in the node. The rest of the nodes updates the number n by adding the number of channels that they are adding to the bus and by subtracting the number of channels that they are blocking or terminating.

In an embodiment of the invention large and fast input power changes are detected, which may be due to a fault, which in its turn would make the number n coming in to the node outdated. In that case the updating of the number n is inhibited until a new and trustable number n is received.

The advantages with the invention is that it is simple, fast and cheap.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a block diagram of a known optical system optimised for five channels in accordance with the prior art.

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Figure 2 shows a block diagram of the same system as in Figure 1, but with only two channels present, and with no amplifier control.

Figure 3 shows an example of a known optical network.

5   Figure 4 shows an example of a node in an optical network that may be used for the implementation of the invention.

Figure 5 shows the optical network of figure 3, with counting of channels according to the invention in nodes without filters.

10   Figure 6 shows the optical network of figure 3, with counting of channels according to the invention in nodes with filters.

Figure 7 shows a detailed view of a first embodiment of the implementation of the counting according to the invention.

15   Figure 8 shows a detailed view of a second embodiment of the implementation of the counting according to the invention.

Figure 9 shows a detailed view of a third embodiment of the implementation of the counting according to the invention.

Figure 10 shows an example of a control circuit where the

20   counting of the channels may be used.

DESCRIPTION OF PREFERRED EMBODIMENTS

Optical amplifiers

Figure 1 shows in accordance with prior art an optical system optimised for five channels 8a, 8b, 8c, 8d and 8e

25   using wavelength division multiplexing. The system can be part of the telephone system for example. In the optical system, an optical amplifier 1 has constant output power. The amplifier 1 is controlled by a pump laser 2. An optical fibre 6 leads into the amplifier 1 from other nodes in the

30   system and an optical fibre 7 leads from the amplifier 1 to

other nodes in the system. In the fibre 6, 7 channels can be added and dropped. In the example shown, four channels 8a, 8c, 8d, 8e come through the first fibre 6 into the amplifier 1, are amplified and exit in the second fibre 7.

5   An additional channel 8b is thereafter added from a transmitter 3. All of the channels 8a, 8b, 8c, 8d, 8e will then be of the same strength and one selected cannel 8d can be read by a filter 4 selecting the specific wavelength of the selected channel 8d and sending it on to a receiver 5.

10   All of the channels 8a, 8b, 8c, 8d, 8e decrease in strength the farther they travel, but since they are of equal strength there is no problem in reamplifying them.

Figure 2 shows the same system as in Figure 1. In this case the system is still optimised for five channels, but only a

15   first channel 8a comes into the amplifier 1. This single channel 8a will then become approximately four times as strong as if there had been four channels which had been amplified. This is due to the fact that the total output power from an optical amplifier is in principal constant,

20   i.e. the output power depends actually primarily on the output power from the pump laser 2 coupled to the amplifier and less on the input power to the amplifier 1.

When a second channel 8b is then added there will be an unbalance between the channels 8a and 8b, which results in

25   problems. The filter 4 is in practice not ideal, so when the filter 4 attempts to select out the second channel 8b, the first channel 8a will predominate since it is so strong and cross talk can occur.

It is thus very desirable to be able to control the output

30   power of channels passing the amplifier 1.

Optical ring network

In figure 3 is shown an example of a known optical ring
network using wavelength division multiplexing, which will
be called a "ring" for short. The ring network in figure 3
5   will be used as a basis for the explanation of the invention
below, but it is to be understood that the invention would
work in other networks as well.

In figure 3 six nodes N1, N2, N3, N4, N5, N6 are connected
to two optical fibres 11, 12 working in opposite directions,
10 that is working as a bi-directional bus. Of course it is
possible to have any number of nodes on the ring.

The place where traffic enters the node from the first fibre
11 and leaves the node on the second fibre 12 will be called
the west port W. The place where traffic enters the node
15 from the second fibre 12 and leaves the node on the first
fibre 11 will be called the east port E. The definition of
"west" and "east" will be connected to this and nothing
else, which means that west may be to the right of east. It
could be helpful to picture the ring as the Equator.

20 Data traffic and signalling from one node to another will be
sent on both fibres 11, 12, that is in both directions.
However, between two of the nodes N1, N6, a segment of the
ring, called an inactive segment IS, does not carry any data
traffic, only signalling. This means that even though data
25 traffic is sent on both fibres, a node will only receive
data traffic from another node on one of the fibres. The
nodes N1, N6 closest to the inactive segment IS will work as
end-nodes. If a fault occurs in a segment on the ring that

is not the inactive segment, then the inactive segment will be moved to encompass the fault.

There are different ways of accomplish the moving of the inactive segment in practise. That is, however, beyond the
5 scope of the present invention. Interested readers may read for example "Electronic letters", 5th December 1996, Vol.32, No 25, p 2338-2339, B.S. Johansson, C.R. Batchellor and L. Egnell: "Flexible bus: A self-restoring optical ADM ring architecture".

10 **Optical nodes**

The most important features of a node in which the invention may be implemented may be seen in figure 4. Other nodes are possible, for example nodes that terminate the channels in each node.

15 On each fibre 11, 12 the node comprises a preamplifier 14, and a booster amplifier 15. The preamplifiers 14 and the booster amplifiers 15 are preferably optical fibre amplifiers (OFA). The preamplifier 15 may work as a switch to accomplish the inactive segment IS, but it is also
20 possible to use the booster amplifier 15 or a separate switch for the purpose.

The node further comprises multiplexers/transmitters 16 for adding wavelength channels to the fibres 11, 12 and demultiplexers/receivers 17 for dropping wavelength channels
25 from the fibres 11, 12.

The node further comprises a central module 18, which in its turn comprises a central processor 19 and a supervisory unit 20. The central processor 19 controls everything. The

supervisory unit 20 sends signalling in a separate
supervisory channel OSC. According to the ITU-T standard
draft G.mcs (Study group 15-contribution, Question: 16/15),
the wavelength of a supervisory channel is preferably
5   1510 nm. Other wavelengths are of course possible.

An advantage with using 1510 nm is that the preamplifiers 14
preferably have a 1530 nm filter implemented to suppress the
gain peak. This filter may be used to block the 1510 nm
supervisory channel. This unnecessitates the use of a
10   separate inline supervisory channel filter or an inline WDM
coupler in the node. However, for the supervisory channel it
could be advantageous of power saving reasons to use a WDM
coupler inline.

The data traffic, that is the data communication channels,
15   on the other hand, may for example use sixteen wavelengths
centred around 1550 nm, with 100 GHz spacing.

Optionally there are also blocking filters 21 between the
preamplifiers 14 and the booster amplifiers 15.

Channel counting

20   As was said above it is desirable to operate the optical
amplifiers in a constant power per channel mode. This could
be done by measuring the total output power and dividing it
with the number of channels passing the amplifier. To do
that it is necessary to know how many channels that are
25   passing the amplifier, which is not as easy to find out as
it sounds.

The basic idea according to the invention, shown in figures
5 and 6, is that each node receives information from the

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node upstreams on the number n of channels present. After having inserted, terminated or blocked channels the node updates the number n and transmits it to next node downstream.

5   The number n could be updated through an electrical network, but it would take several tens of seconds for the updated number n to be distributed to all the amplifiers. This could mean a performance degradation of the traffic signals during the time to update the number n. A better idea is probably
10 to use the aforementioned optical supervisory channel OSC.

As was said earlier, a node transmits data in both directions. The same wavelength is preferably used to communicate from a first node N1 to a second node N2, as from the second node N2 to the first node N1.

15 If there is not a blocking filter in the second node N2, a channel received in the second node N2 is not terminated or blocked in the second node, but passes and continues downstream. If there had not been an inactive segment IS it would in this case not work to use the same wavelength.
20 That is because data from the first node would be mixed with data from the second node and thus become unreadable. However, the inactive segment introduces a break in the ring, which stops the data traffic.

This means that on the paths between the first N1 and the
25 second N2 nodes where the inactive segment IS is not situated, data is not mixed. On the other hand, on the paths between the first N1 and the second N2 nodes where the inactive segment IS is situated, data will be mixed.

This is of no importance, since that mixed data is stopped by the inactive segment IS and is not read anyway.

This is a very simple solution. However, on each wavelength used, two channels will be superimposed in certain parts of the ring. This means that the power of a wavelength is doubled and that the amplifiers in the nodes have to count that wavelength as two channels in those parts of the ring.

This is perhaps more clarified in the example in figure 5, which is the same as figure 3. The first node N1 transmits five channels on the following wavelengths: $\lambda 1$ destined for the second node N2, $\lambda 2$ destined for the third node N3, $\lambda 3$ destined for the fourth node N4, $\lambda 4$ destined for the fifth node N5 and finally, $\lambda 5$ destined for the sixth node N6. Since the first node N1 is an end-node, data is only transmitted eastwards, n=5.

The second node N2 transmits five channels on the following wavelengths: $\lambda 1$ destined for the first node N1, $\lambda 6$ destined for the third node N3, $\lambda 7$ destined for the fourth node N4, $\lambda 8$ destined for the fifth node N5 and finally, $\lambda 9$ destined for the sixth node N6.

The second node N2 receives a channel from the first node N1 on wavelength $\lambda 1$ and transmits a channel to the first node N1 on the same wavelength $\lambda 1$. On the east path from the second node N2 to the first node N1 the wavelength $\lambda 1$ will thus contain two superimposed channels (which, however, are stopped at the input of the first node N1 or at the output of the sixth node N6, due to the inactive segment). These two channels are not readable at the

moment, but must anyway be counted as two, since the power level is doubled.

Hence, the second node N2 transmits eastwards the five channels on the wavelengths $\lambda 1$-$\lambda 5$ from the first node N1 adding five channels on the wavelengths $\lambda 1$, $\lambda 6$-$\lambda 9$. Thus, there are nine wavelengths used, but ten channels, n=10.

The third node N3 transmits five channels on the following wavelengths: $\lambda 2$ destined for the first node N1, $\lambda 6$ destined for the third node N3, $\lambda 10$ destined for the fourth node N4, $\lambda 11$ destined for the fifth node N5 and finally, $\lambda 12$ destined for the sixth node N6.

Hence, the third node N3 transmits eastwards the ten channels on the wavelengths $\lambda 1$-$\lambda 9$ from the first N1 and second N2 nodes, adding five channels on the wavelengths $\lambda 2$, $\lambda 6$, $\lambda 10$-$\lambda 12$. Thus, there are twelve wavelengths used, but fifteen channels, n=15.

The fourth node N4 transmits five channels on the following wavelengths: $\lambda 3$ destined for the first node N1, $\lambda 7$ destined for the second node N2, $\lambda 10$ destined for the fifth node N5, $\lambda 13$ destined for the fifth node N5 and finally, $\lambda 14$ destined for the sixth node N6.

Hence, the fourth node N4 transmits eastwards the fifteen channels on the wavelengths $\lambda 1$-$\lambda 12$ from the first N1, second N2 and third N3 nodes, adding five channels on the wavelengths $\lambda 3$, $\lambda 7$, $\lambda 10$, $\lambda 13$, $\lambda 14$. Thus, there are fourteen wavelengths used, but twenty channels, n=20.

The fifth node N5 transmits five channels on the following wavelengths: $\lambda 4$ destined for the first node N1, $\lambda 8$ destined for the second node N2, $\lambda 11$ destined for the third node N3, $\lambda 13$ destined for the fourth node N4, and finally, $\lambda 15$ destined for the sixth node N6.

Hence, the fifth node N5 transmits eastwards the twenty channels on the wavelengths $\lambda 1$-$\lambda 14$ from the first N1, second N2, third N3 and fourth N4 nodes, adding five channels on the wavelengths $\lambda 4$, $\lambda 8$, $\lambda 11$, $\lambda 13$, $\lambda 15$. Thus, there are fifteen wavelengths used, but twenty-five channels, n=25.

Finally, the sixth node N6 transmits five channels on the following wavelengths: $\lambda 5$ destined for the first node N1, $\lambda 9$ destined for the second node N2, $\lambda 12$ destined for the third node N3, $\lambda 14$ destined for the fourth node N4, and finally $\lambda 15$ destined for the fifth node N5.

The sixth node N6 transmits data both eastwards and westwards, but data eastwards is stopped by the inactive segment.

However, the sixth node N6 transmits five channels westwards on the wavelengths $\lambda 5$, $\lambda 9$, $\lambda 12$, $\lambda 14$, $\lambda 15$. This ends up to fifteen wavelengths used around the ring corresponding to thirty channels, n=30. In another network, without an inactive segment IS, there would have been a necessity of thirty wavelengths corresponding to the thirty channels. The counting would be the same, however, since it is the channels that are counted.

The sixth node N6, being an end-node resets the number of channels n westwards, adding the number of active

transmitters, n=5. Then the same procedure happens westwards as was explained eastwards, n=10, n=15, n=20, n=25, (n=30), each node using the same wavelengths both eastwards and westwards.

5   The equation for calculating the number of channels in figure 5 will be $n_y = n_x + z$, where n_x equals the number n coming in to the node, n_y equals the number n going out from the node, and z equals the number of channels added in the node, that is the number of active transmitters in the node.

10 Figure 6 shows the same network as figure 5, but the optional filter 21 is used in all nodes N1-N6. This is more expensive, but on the other hand no "double" channels will have to be amplified. The filter in a node removes the same wavelengths that are used for transmitting from and
15 receiving to the node. In the figure the blocked wavelengths are marked by strikethrough λ1.

On the east path from the second node N2 to the first node N1 the wavelength λ1 will thus not contain two superimposed channels, but only the channel that the second node N2
20 transmits to the first node N1. Hence, the number of channels will equal the number of wavelengths, that is nine, n=9.

The same will happen further eastwards in the other nodes, compare the calculation of wavelengths in figure 5: n=5
25 n=9, n=12, n=14, n=15, (n=15), ending up with fifteen channels on fifteen wavelengths. Of course, the corresponding will happen also westwards.

Hence, the equation for calculating the number of channels in figure 6 will be $n_y = n_x + z -w$, where n_x equals the

number n coming in to the node, n_y equals the number n going
out from the node, z equals the number of channels added in
the node, and w equals the number of channels blocked in the
node.

5   Assuming that all received channels are blocked in a node,
then the number of blocked channels w will be equal to the
number of active transmitters in the node.

The equation is equally true for figure 5, but with w=0.
The equation would also be true for a network terminating
10   the channels in each node, with w denoting blocked or
terminated channels in the node.

In figure 7 is shown the principle function of an update of
the number n in a node like the one in figure 4 or similar.
The incoming number of channels n_x is used to update the
15   preamplifier 14. The outgoing number of channels n_y is used
to update the booster amplifier 15. As was said above, the
outgoing number of channels n_y is calculated according to
$n_y = n_x + z - w$, where z equals the number of channels added,
and w equals the number of channels blocked or terminated,
20   if any.

The process is started with an end-node setting the first
number n to the number of active transmitters in the end-
node, thus indicating the number of channels.

This is all nice and simple, but in the real world things
25   happen: transmitters may failure, fibres may break or be
bent, etc. We have to make sure that the amplifier is not
updated with an outdated number n.

A small change of the number n will not influence much if the number n is large. It is the big changes that are mainly interesting. Thus, a input power change limit ΔP which is acceptable is set and measured on the inputs of both the preamplifier 14 and the booster amplifier 15.

If the input power change is less then ΔP, we do not bother at all. If, however, an amplifier detects an input power change greater then ΔP, the amplifier sends an input power change flag ΔPin to the optical supervisory unit 20. It may than be an attenuation change on the line, added/removed transmitters or a fault which has caused the inactive segment to move. In the last case the path proceeding the node could contain a number n that is out of date.

The node, however does not know why the big input power change has occurred. To prevent the node from updating the amplifier with an outdated number n, an inhibit flag is sent internally in the amplifier as soon as the input power change is detected, see also figure 10.

This inhibits further updating of the number n until the optical supervisory unit has received a number n that it trusts. Then the optical supervisory unit sends a reset flag to the amplifier(s), which once again allows updating of the number n.

For a 80 km node-to-node distance a delay time of about 400 μs is needed. After the delay, the optical supervisory unit 20 probably needs to read one frame plus the next coming cyclic redundancy check CRC before it can do an update. That would result in a total delay of about 525 μs.

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A suitable value for the input power change limit ΔP would probably be about 0,5 to 1 dB. Then a change from for example ten to eleven channels will not be noticed, but a change from one to two channels will be detected and of

5   course also a fault which causes the inactive segment to move.

If an input power change flag ΔPin is received from the booster amplifier 15, but not from the preamplifier 14, then there is probably a transmitter fault in the node. Then, the

10   update of the number n_y for the booster amplifier will be inhibited until the optical supervisory unit has received a number n_x that it trusts. This is a fast way of detecting transmitter faults, but is mainly intended for the control of the amplifiers. If there are many channels a transmitter

15   fault will not be noticed, but that on the other hand is no problem for the amplifier. Of course the transmitters should be observed for faults in a usual (slower) way too.

In figure 7 there are hardwired buses from the optical supervisory unit 20 to the amplifiers 14, 15 and hard wires

20   to the transmitters 16. Another alternative would be, like in figure 8, to use the central unit 19 to supply the amplifiers 14, 15 with the current number of channels n. The optical supervisory unit 20 then makes an update with a trigger signal. A prerequisite in this case, when the first

25   channel is started in the network, is that the amplifiers 14, 15 have a default value of the number n=1. Otherwise it would take too long before the power levels have been adjusted.

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A third way could be to have hardwired buses to the amplifiers 14, 15, but letting the central unit 19 taking care of the transmitters 16, see figure 9.

In the figures 7-9 the amplifiers 14, 15 also transmits a loss of power flag LOP. This is an indication of a fault on the incoming side of the amplifier. In the case of the preamplifier 14, this is an indication that the inactive segment IS should be moved to this place. Thus, the node becomes an end-node and the number n must be changed to the number of active transmitters in the node.

Amplifier control

The actual control of the amplifiers could be implemented with feed-forward and feedback, as in figure 10. What in earlier figures was called an optical amplifier corresponds to the whole of figure 10. An erbium doped fibre 31, working as amplifier, is controlled by a pump laser 32. A first detector 33 reads the total optical power at the input of the erbium doped fibre 31 and forwards the value to a feed-forward block 34. From the feed-forward block 34 a feed-forward process demand signal PF is sent which controls the erbium doped fibre 31 by controlling the output power of the pump laser 32.

The feed-forward block 34 provides a preferably non-linear function of the total optical power and can be realised with the aid of an analogue non-linear network, for example. Another alternative is to solve it digitally by A/D converting the optical input power into an eight-bit-word, for example. This eight-bit-word can then be used by

different values of the eight-bit-word indicating different
memory addresses in a memory.

The feedback functions by measuring the output power of the
erbium doped fibre 31 by a detector 36. The output power

5   goes to a feedback block 37, where it is divided with the
number of channels n, thereby providing a process value PV.
In a controller 35 the process value PV is compared to the
desired channel output power, i.e. a set point SP. In
accordance with the programming of the controller 35, the

10   controller 35 emits a feedback process demand signal PB
which controls, via the pump laser 32 the channel output
power of the erbium doped fibre 31, so that it approaches
the desired output.

This adjustment does not of course take place

15   instantaneously. When the feedback process demand signal PB
via the pump laser 32, changes the channel output power of
the erbium doped fibre 31, the conditions may already have
been changed, which would require a new measurement of the
channel output power of the erbium doped fibre 31, thus

20   providing a new feedback process demand signal PB. This
process takes place continually and a negative feedback
control loop is created which, with a certain time delay,
adjusts the output power of the erbium doped fibre 31 so
that it is always in the vicinity of the desired value.

25   To use feed-forward makes the control rapid, since
disturbances can be corrected at once. Feed forward
requires, however, much knowledge of the behaviour of the
system, since the result cannot be seen. It can be compared
to driving a car blindfolded; one must know exactly how

much to turn the wheel at each curve in order not to end up in the ditch.

Negative feedback, on the other hand, is reliable since the result is observed and adjustments are made thereafter. The
5   disadvantage is that the automatic control cannot be effected however rapidly one may wish, since the control will then risk becoming unstable. In this case the optical amplifier also has a time constant of about 2-3 ms, which sets a limit to how rapid the feedback control can be made.
10   If one combines, however, the feedback with the feed-forward, a rapid rough adjustment is achieved with the aid of the feed-forward and a not so rapid fine adjustment is achieved with the aid of the feedback.

Figure 10 shows a combination means 38 which combines the
15   feed-forward process demand signal PF with the feedback process demand signal PB and provides an output signal PD, for the control of the pump laser 32. The combination block 18 can be an adder or a multiplier, but also other combination functions are conceivable.

20   The detector 33 at the input of the amplifier provides the loss of power flag LOP. The feed-forward block 34 provides the input power change flag ΔPin via a flip-flop 39. The flip-flop 39 is reset by the reset signal from the optical supervisory unit.

25   The feedback block 37 receives the number of channels n and a trigger signal, if any. In addition, the feedback block 37 receives the input power change flag ΔPin from the flip-flop 39, which inhibits updating of the number n.

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The setpoint SP and the level of the loss of power flag LOP
may be setable from the central processor 19.

This was an example of a control circuit. The feed forward
and feed back loops may also be used separately.

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CLAIMS

1. Method for controlling the output power of an optical amplifier (14, 15) in a node (N1, N2, N3, N4, N5, N6) in a network, wherein output power of the amplifier (14, 15) is

5 controlled via a pump laser (32) in a control circuit, c h a r a c t e r i z e d in that the node (N1, N2, N3, N4, N5, N6) reads a supervisory channel (OSC), comprising information on how to control the amplifier (14, 15) and in that the node (N1, N2, N3, N4, N5, N6) uses said information

10 for the control of the amplifier (14, 15).

2. Method according to claim 1, c h a r a c t e r i z e d in that the information comprises the number of channels coming in to the node.

3. Method according to claim 2, c h a r a c t e r i z e d in

15 that total output power from the amplifier (14, 15) is measured and divided with the number of channels (n, n_x) coming in to the node (N1, N2, N3, N4, N5, N6), which gives the total output power per channel, which is used for the control of the amplifier (14, 15).

20 4. Method according to claim 2, c h a r a c t e r i z e d in that the node (N1, N2, N3, N4, N5, N6) obtains a new number of channels (n, n_y) for transmission to a node (N1, N2, N3, N4, N5, N6) downstreams by, to the number of channels (n, n_x) coming in to the node adding the number of added channels

25 (z) in the node and subtracting the number of blocked or terminated channels (w) in the node.

5. Method according to claim 4, c h a r a c t e r i z e d in that total output power from the amplifier is measured and divided with the new number of channels (n, n_y), which gives

the total output power per channel, which is used for the control of the amplifier (14, 15).

6.   Method   according   to   claim   4   or   5,
c h a r a c t e r i z e d in that the number of added
channels (z) is obtained from the number of active
transmitters (16) in the node.

7.   Method   according   to   any   of   the   claims   2-6,
c h a r a c t e r i z e d   in   that   input   power   to   the
amplifier (14, 15) is monitored and that an input power
change flag (ΔPin) is set if the input power is changed more
than a certain limit.

8. Method according to claim 7, c h a r a c t e r i z e d in
that the set input power flag (ΔPin) inhibits further change
of the control of the amplifier (14, 15), until a reliable
number of channels (n, n_x) is received.

9.   Method   according   to   any   of   the   claims   2-8,
c h a r a c t e r i z e d in that the number of channels (n,
n_x, n_y) is sent to the control circuit for use directly.

10.   Method   according   to   any   of   the   claims   2-8,
c h a r a c t e r i z e d in that the number of channels (n,
n_x, n_y) is sent to the control circuit, but is not used until
a trigger signal (Trig) is sent to the control circuit.

11. Node in a network comprising a central processor (19), a
supervisory unit (20) and at least one optical amplifier
(14, 15), whose output power is controlled via a pump laser
(32) in a control circuit, c h a r a c t e r i z e d in that
the node is disposed to read information sent in a

supervisory channel (OSC) for the control of the amplifier (14, 15).

12. Node according to claim 11, c h a r a c t e r i z e d in that the information comprises the number of channels (n, n_x) coming in to the node.

13. Node according to claim 12, c h a r a c t e r i z e d in that the node is disposed to measure total output power from the amplifier (14, 15) and to divide it with the number of channels (n, n_x) coming in to the node.

14. Node according to claim 12, c h a r a c t e r i z e d in that the node is disposed to obtain a new number of channels (n, n_y) for transmission to a node downstreams by, to the number of channels (n, n_x) coming in to the node, adding the number of added channels (z) in the node and subtracting the number of blocked or terminated channels (w) in the node.

15. Node according to claim 14, c h a r a c t e r i z e d in that the node is disposed to measure total output power from the amplifier (14, 15) and to divide with the new number of channels (n, n_y).

16. Node according to claim 14 or 15, c h a r a c t e r i z e d in that the node is diposed to obtain the number of added channels (z) from the number of active transmitters (16) in the node.

17. Node according to any of the claims 12 to 16, c h a r a c t e r i z e d in that the node is disposed to monitor input power to the amplifier and to set a input power change flag (ΔPin) if the input power is changed more than a certain limit.

18 Node according to claim 17, c h a r a c t e r i z e d in
that the set input power flag (ΔPin) is disposed to inhibit
further change of the control of the amplifier (14, 15),
until a reliable number of channels (n, n$_x$) is received.

5   19. Node according to any of the claims 12 to 18,
c h a r a c t e r i z e d in that the optical supervisory
unit (20) is disposed to transmit the number of channels (n,
n$_x$, n$_y$) to the control circuit for use directly.

20. Node according to any of the claims 12 to 18,
10   c h a r a c t e r i z e d in that the central processor (19)
is disposed to transmit the number of channels (n, n$_x$, n$_y$) to
the control circuit, and that the optical supervisory unit
(20) is disposed to transmit a trigger signal (Trig) to the
control circuit.

15   21. Network, comprising at least two nodes (N1, N2, N3, N4,
N5, N6, N6), communicating over at least one communication
path (11, 12), each node (N1, N2, N3, N4, N5, N6, N6)
comprising at least one optical amplifier (14, 15), whose
output power is controlled via a pump laser (32) in a
20   control circuit, c h a r a c t e r i z e d in that
information sent in a separate channel (OSC) is provided for
control of the amplifier(s) (14, 15).

22.   Network,   according   to   claim   21,
c h a r a c t e r i z e d in that the information coming in
25   to a node (N1, N2, N3, N4, N5, N6, N6) comprises the number
of channels (n, n$_x$, n$_y$) coming in to the node (N1, N2, N3,
N4, N5, N6, N6).

23. ·· Network,   according   to   claim   22,
c h a r a c t e r i z e d in that each node (N1, N2, N3, N4,

N5, N6, N6) is disposed to obtain a new number of channels (n, n_y) for transmission to a node (N1, N2, N3, N4, N5, N6, N6) downstreams by, to the number of channels (n, n_x) coming in to the node, adding the number of added channels (z) in
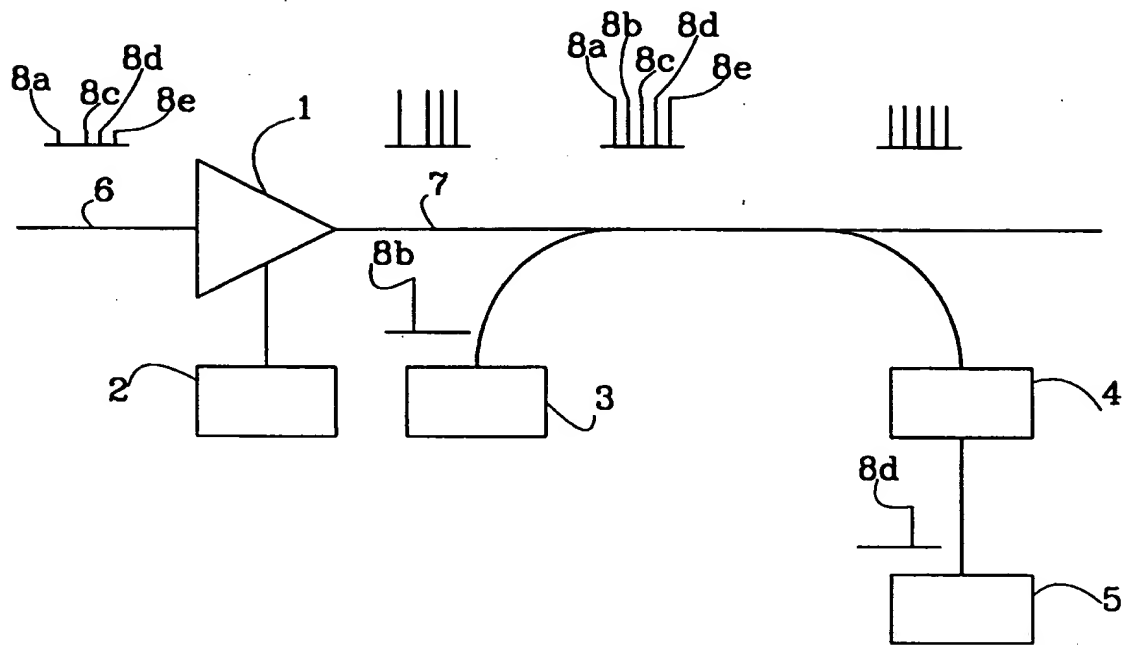5   the node and subtracting the number of blocked or terminated channels (w) in the node.
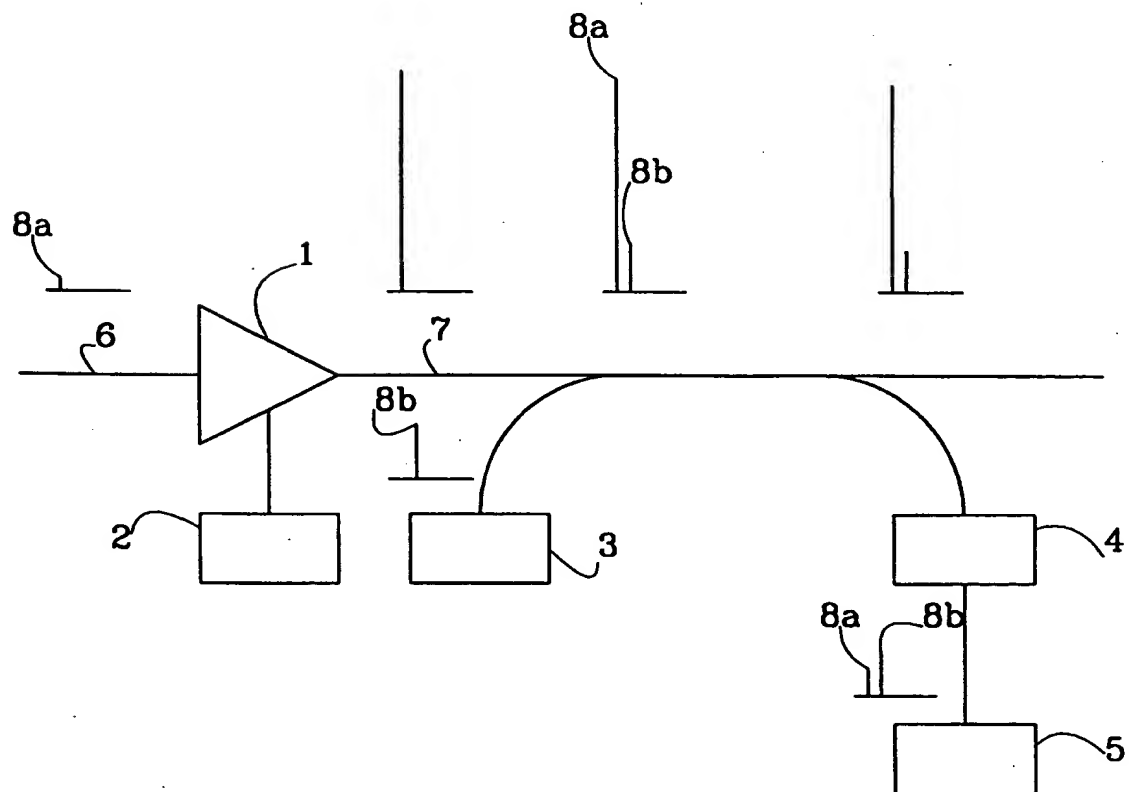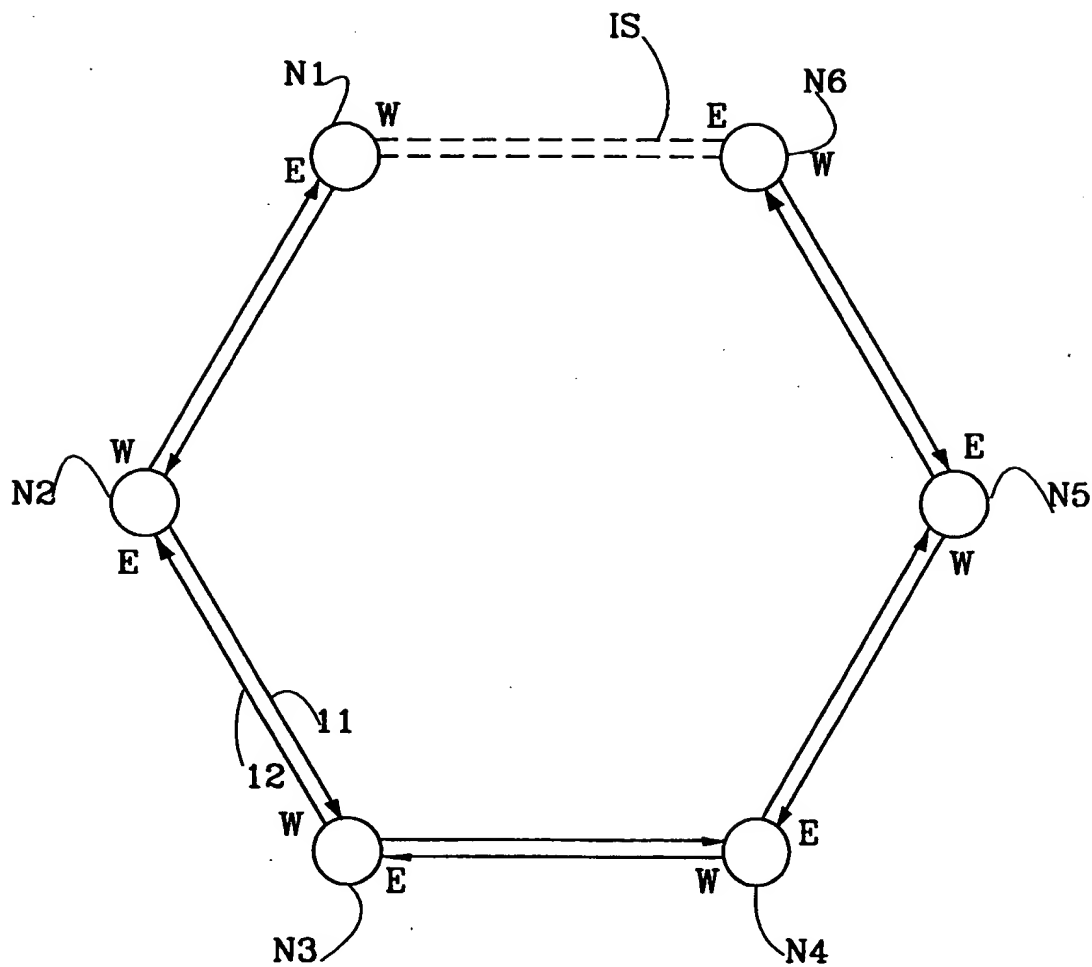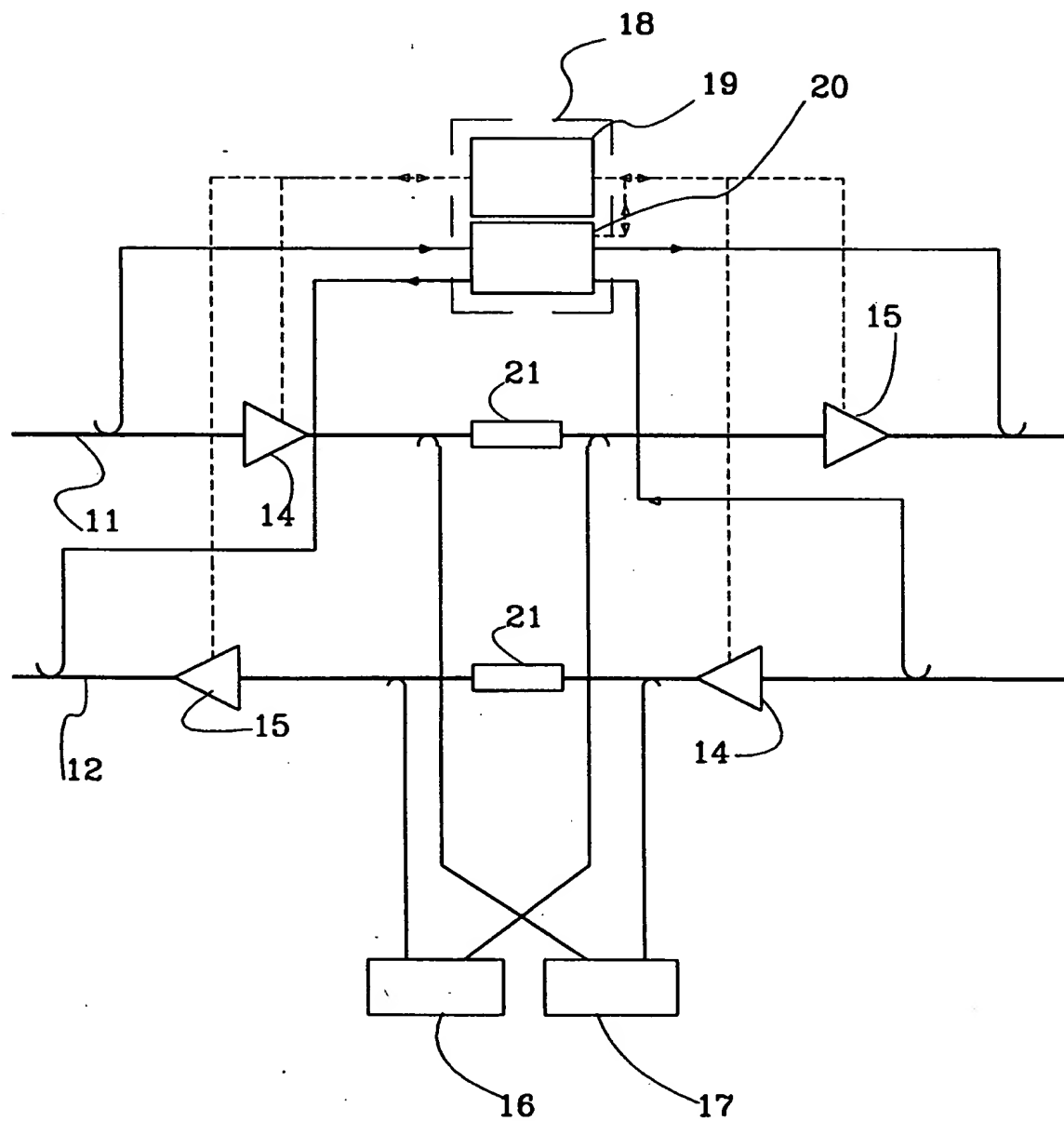
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FIG 1

FIG 2

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FIG 3

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Fig 4

λ1,λ2,λ3,λ4,λ5

λ5,λ9,λ12,λ14,λ15

IS

N1

W   (n=30)   E   N6

E   (n=30)   W

n=25
n=5

n=25
n=5

W
N2
E

E
N5
W

n=20   n=10

n=20   n=10

λ1,λ6,λ7,λ8,λ9

λ4,λ8,λ11,λ13,λ15

11

12

W   n=15   E

E   n=15   W

N3

N4

λ2,λ6,λ10,λ11,λ12

λ3,λ7,λ10,λ13,λ14

FIG 5

λ1,λ2,λ3,λ4,λ5   λ5,λ9,λ12,λ14,λ15

                    IS

N1   N6
        W   (n=15)   E
        ═══════════════
    E   W
        (n=15)

    n=15   n=15
        n=5   n=5

    W   E
N2   N5
    E   W

λ1,λ6,λ7,λ8,λ9   λ4,λ8,λ11,λ13,λ15

    n=14   n=9   n=14   n=9

λ1,λ6,λ7,λ8,λ9
        11
                                    λ4,λ8,λ11,λ13,λ15
        12
    W   E
        n=12
        ═══════════════
    E   n=12   W

N3   N4

λ2,λ6,λ10,λ11,λ12   λ3,λ7,λ10,λ13,λ14

FIG 6

FIG 7

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FIG 8
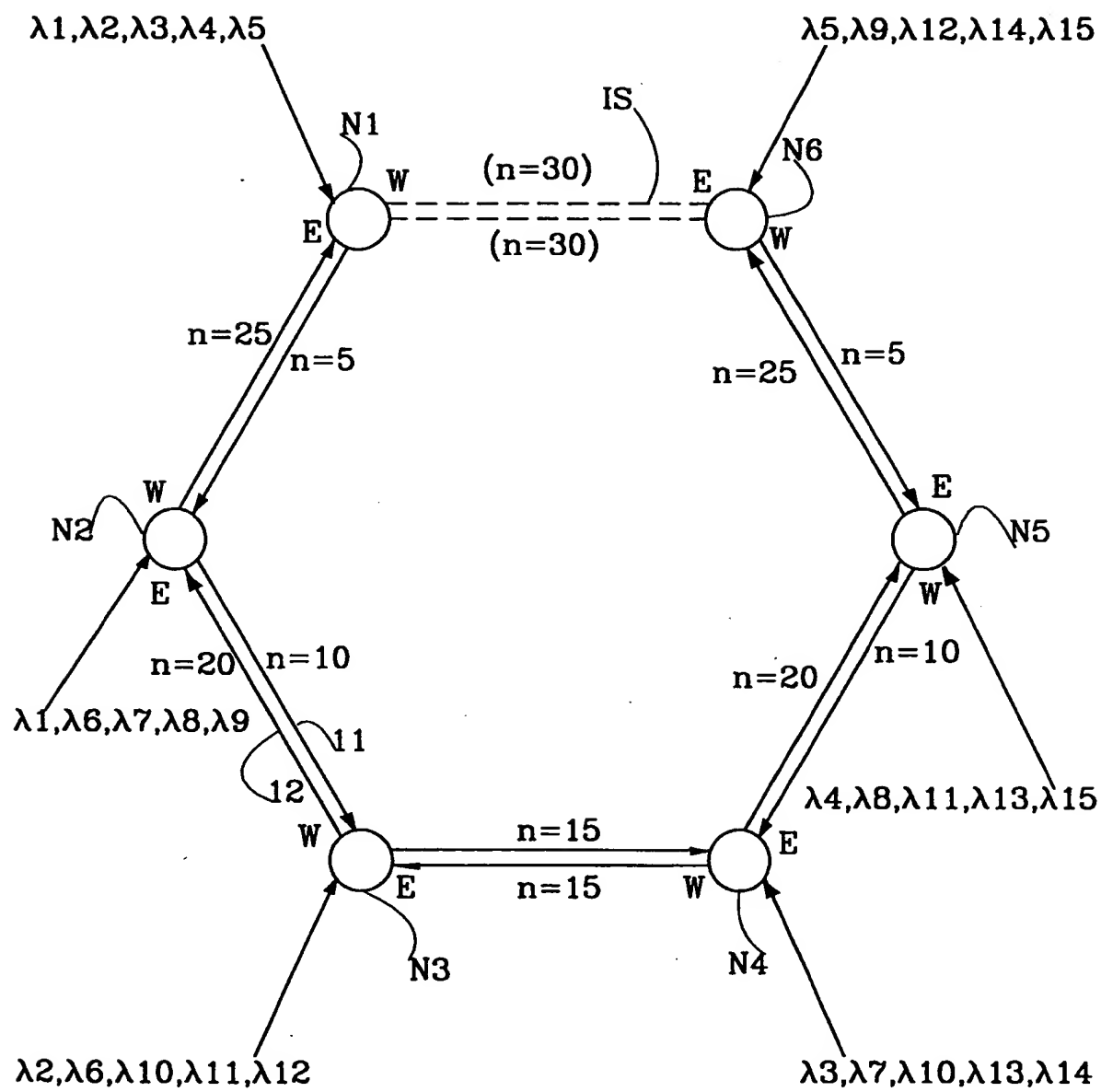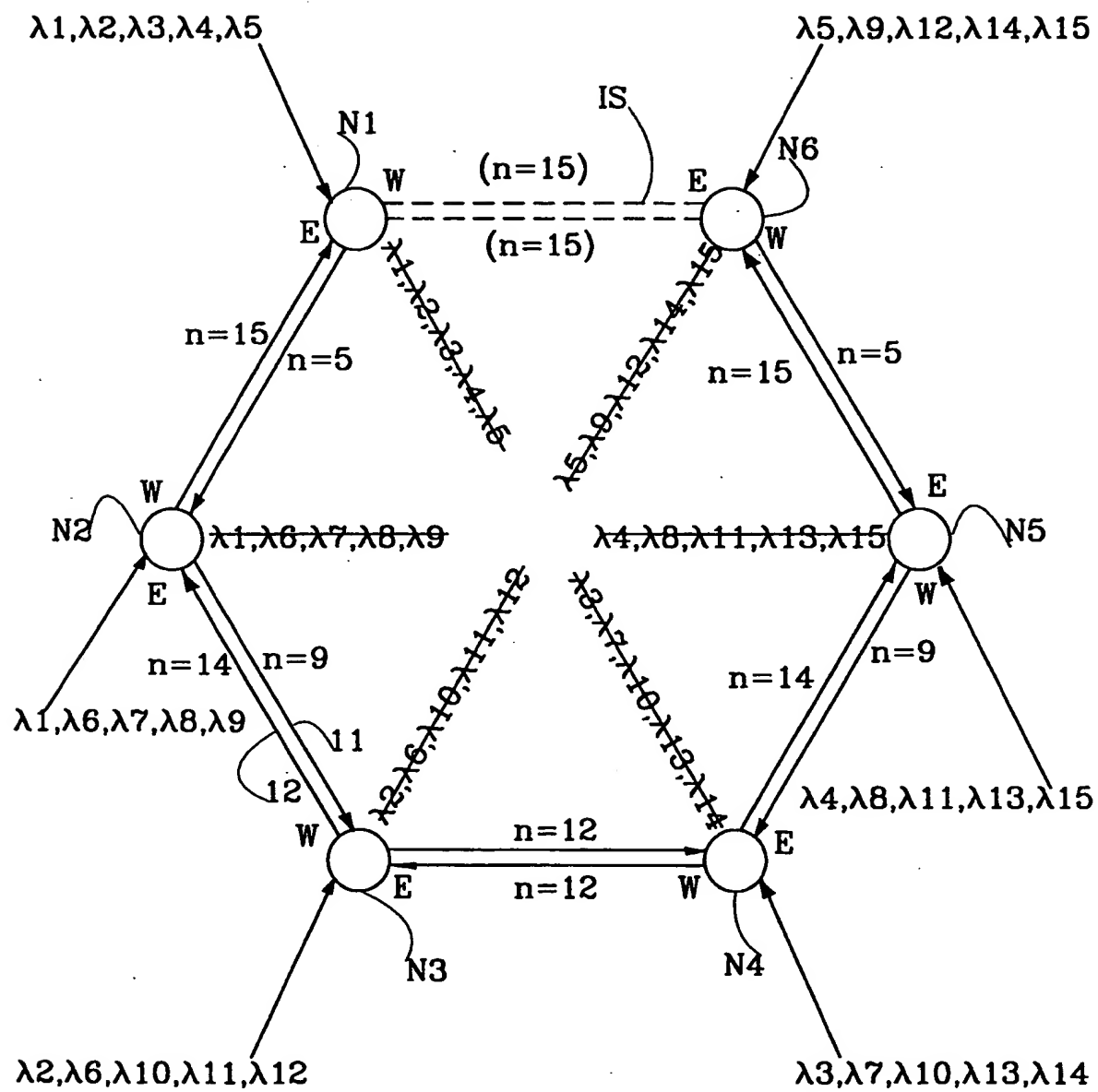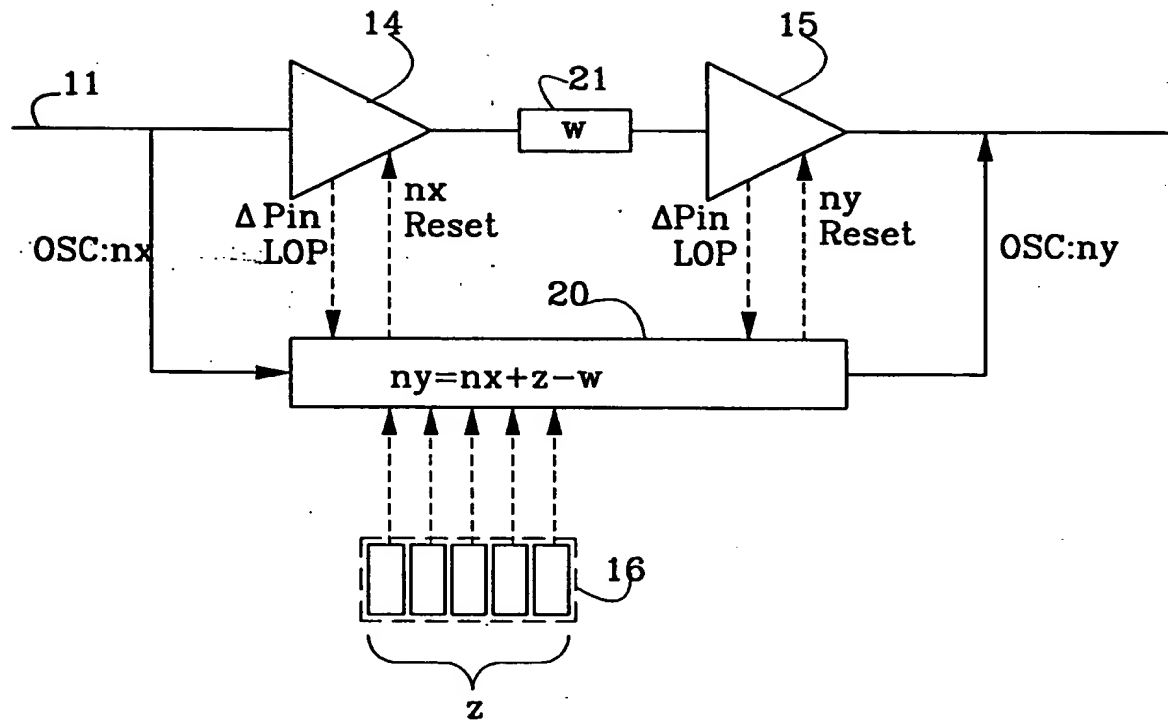
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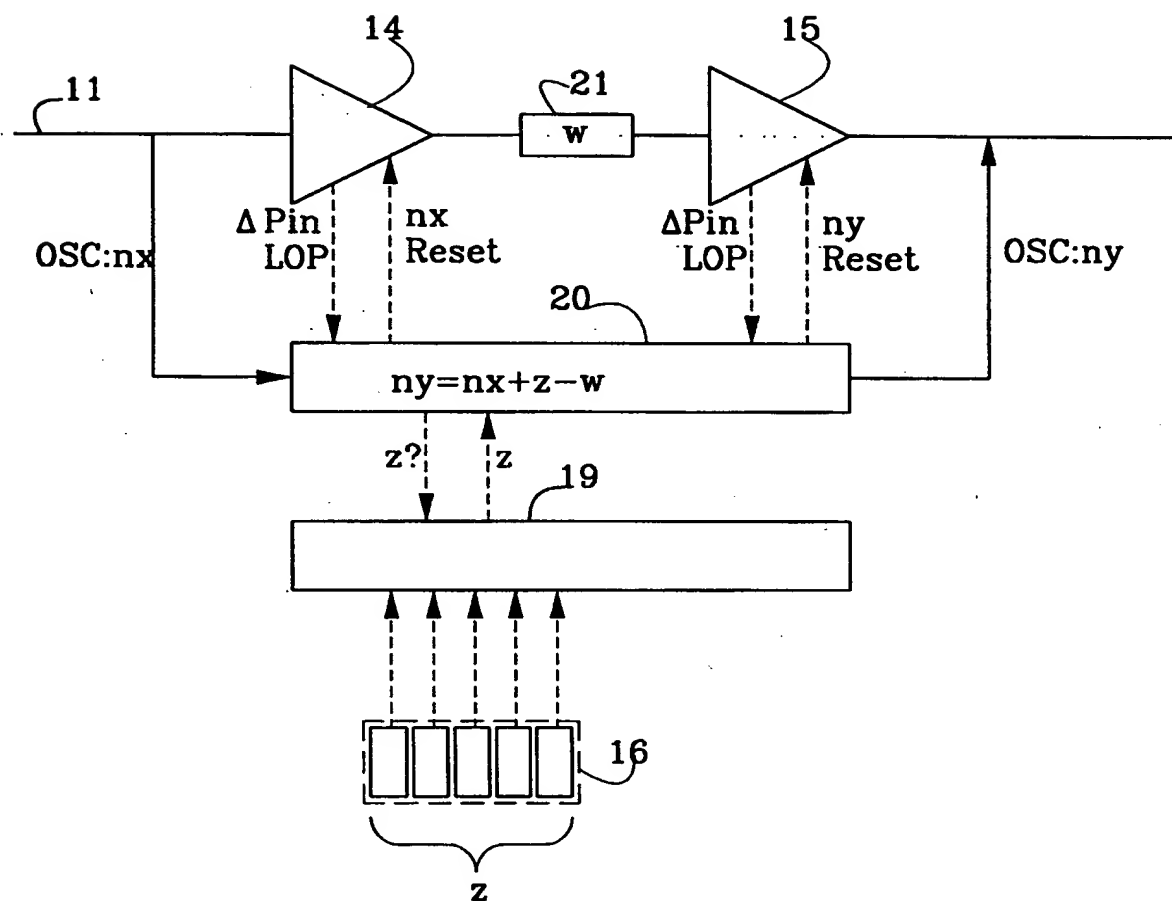
FIG 9

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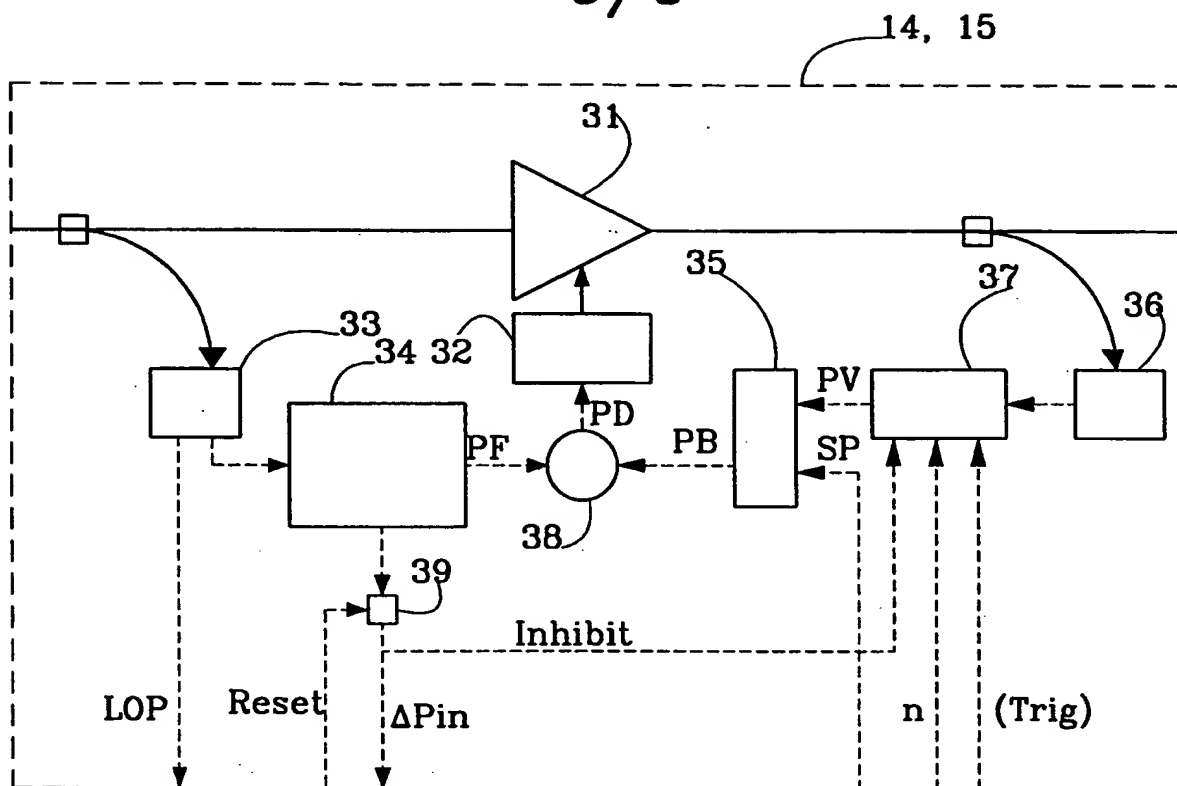
FIG 10

INTERNATIONAL SEARCII REPORT

	International application No.
	PCT/SE 98/01795

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 10/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

Date of the actual completion of the international search	Date of mailing of the international search report
12 March 1999	1 6 -03- 1999
Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Irenne Turcu Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

| International application No. |
| PCT/SE 98/01795 |

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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